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PhD THESIS

RESEARCH ON THE BEHAVIOUR OF SOME CULTIVARS OF STRAWBERRIES IN CLASSIC AND ECOLOGYCAL SYSTEMS IN TRANSYLVANIAN TABLELAND PEDOCLIMATIC CONDITIONS

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INTRODUCTION

Nutritional and organoleptic qualities of the fruit (taste and special flavor, rich in vitamin C), are good sources of natural antioxidants (Wang et al., 1996; Heinonen et al., 1998.) Including carotenoids, vitamins, phenols, suitability to domestic processing and its great ecological adaptability afforded by the high potential of genetic variability, caused a large-scale expansion of areas planted with strawberries in the world and in our country.

PhD thesis, wants to improve some aspects of technology culture, taking into account the changing assortment, improve quality, climatic conditions, changing, some aspects of culture technology.

THE PURPOSE AND OBJECTIVES OF PhD. THESIS

Research within this thesis have started from the premise that technology culture of this species in Romania have improved. The application of differentiated technologies, according to the variety and growing conditions, ensuring the achievement of high yields, consistent and quality from one year to another. In this respect it was considered useful to study agro system and new varieties to better promote their subsequent production. Given the need to test new varieties prior to their introduction in culture, and detailed knowledge of their requirements to the environmental conditions of this thesis research is intended to be a set of solutions to these problems.

The aim of the thesis was a comparative study of ten varieties of strawberries, perennial crops field in the climatic conditions of the Transylvanian tableland. 

To achieve its purpose the following objectives were set:

- Improving soil maintenance with focus on using different types of mulch.
- Continue research on phytochemical fruit and plant parts with the double role food and herbal.
- Development of new culture systems, including organic farming, fertilizer recipes with macro and micro elements and fertigation.
- Improving complexes against pathogens and pests strawberry culture that conventional organic products in the EU accepted.
- Improving strawberry crop in the field.
- Study the behavior of newly introduced varieties of strawberry culture in terms of the Transylvanian Tableland, to the recommendation for the valuable culture.

**BIOLOGICAL MATERIAL AND RESEARCH METHODS**

Research on the behavior of the ten varieties of strawberry in climatic conditions in Transylvania were performed in a polifactorial experiences during the two years after the Latin rectangle method, located on the farm SC SERIM IMPEX SRL, Cluj Napoca.

The biological material used in the experience was the ten varieties of strawberry (‘Alba’, ‘Premial’, ‘Kimberly’, ‘Korona’, ‘Elliany’, ‘Elsanta’, ‘Vima Zanta’, ‘Viktoriana’, ‘Virena’ and ‘Vima Xima’) widespread in countries with advanced horticulture which for our country are new.
The experimental design was a complete polifactorial Latin rectangle design and factors used in the experiment were system fertilization with two graduations, mulch system with three graduations and cultivar with ten graduations.

- **Factor A – fertilizer**
  - a₁ – poultry manure
  - a₂ – chemical

- **Factor B – mulch**
  - b₁- agrotekstil
  - b₂- black foil
  - b₃- straw

- **Factorul C – variety**
  - c₁ - ‘Alba’
  - c₂- ‘Premial’
  - c₃- ‘Kimberly’
  - c₄- ‘Korona’
  - c₅- ‘Elianny’
  - c₆- ‘Elsanta’
  - c₇- ‘Vima Zanta’
  - c₈- ‘Viktoriana’
  - c₉- ‘Virena’
  - c₁₀- ‘Vima Xima’

During the experience there have been a number of morphological characters and phenological observations on strawberry culture, namely:

- **Phenological observations:**
  - Vegetation;
  - Appearance of inflorescences;
  - Ascension of inflorescences;
  - Complete flowering;
  - Start the binding of fruit;
  - Fruit maturation;
  - Date of last harvest;
  - Number of days from flowering to harvest.

- **Determination of vegetative morphological characters:**
  - Plant heigh;
  - Length of petiole;
  - The index of the form;
  - The number of leaves per plant.
o Determination of vegetative morphological characters:
  - The percentage of the binding flowers (%);
  - Size of the fruit, (g, cm);
  - Structo-textural firmness of strawberry (kgf/cm²);
  - Adherence of calyx.

o Chemical determination:
  - The content of total soluble dry matter (%).
  - The average content in soluble solids content (%).
  - The medium content of sugar (°Bx).
  - Total titratable acidity (%).
  - Vitamin C content (mg/100g fresh fruit).

RESULTS ON SOME PHENOLOGY ASPECTS

Experimental data were presented as the average of the two experimental years using Duncan test for statistical analysis and to establish relationships between different variables have made a series of correlations.

Vegetation. ‘Premial’ was first started growing at' (16 March) followed by ‘Alba’ (18 March), ‘Kimberly’ (19 March) and the last ‘Virena’ (30 March). The vegetation occurred simultaneously to ‘Elianny’ and ‘Elsanta’ (23 March) and the other cultivars started in vegetation in succession in the last decade of March.

Appearance of inflorescence. The average date of appearance of inflorescence in the experimental period 2012 - 2013 was April 20, a date that can be considered the benchmark for flowering strawberry in Cluj-Napoca.

Ascension of inflorescences. The first cultivar that has started this phenophase was ‘Premial’ in both 2012 and 2013, followed closely by ‘Alba’. Last cultivar that has been running this phenophase was ‘Virena’.

Complete flowering. The first cultivars at complete flowering which began in 2012 was ‘Premial’ and ‘Korona’ (27 May), and in 2013, cultivar ‘Premial’ (26 April). In 2012, cultivars ‘Alba’, ‘Kimberly’, ‘Elianny’ and ‘Vima Zanta’ flourished in the same
day (28 May). Last cultivars from which phenophases was observed were ‘Virena’ and ‘Vima Zanta’.

**Binding early fruit.** First fruits tied cultivars were ‘Premial’ and ‘Alba’ both in 2012 and 2013 and the last was ‘Virena’ and in 2012 was ‘Vima Xima’ in 2013.

**Fruit maturation.** The average date of the beginning of fruit ripening in 2012 - 2013 was June 12. This date may be considered for ripening strawberry tableland in the city of Cluj-Napoca.

**Number of days from flowering to harvest.** The lower number of days from flowering to harvest maturity was 32 days and was registered in 2012, by the cultivar ‘Alba’, and the highest value was 40 days to cultivar ‘Vima Xima’.

The average number of days after flowering to harvest maturity was 34 days. This means that on the climatic conditions of Cluj-Napoca, strawberry cultivars fructifies within 34 days after flowering.

**Plant height.** From the ten cultivars that were studied cultivars ‘Elianny’ and ‘Vima Zanta’ stands out with the highest plant height (29.50 cm and 29.00 cm and the lowest value in terms of plant height was obtained by the cultivar ‘Alba’ (20.83 cm), and medium values were identified in cultivars ‘Kimberly’, ‘Viktoriana’ and ‘Virena’ (22.17 cm and 22.75 cm).

Plants reached the highest height in NPK fertilization 26.72 cm and 24.48 cm in organic fertilization.

**Length of Petiole.** Regardless of the type of fertilizer applied, the highest value was recorded in cultivar ‘Vima Zanta’ (23.66 cm), followed on significant differences cultivars ‘Premial’ (21.38 cm), ‘Elsanta’ (21.09 cm), and ‘Korona’ (20.29 cm).

**The index of the form.** Foliar index values were within the organic fertilization between (1.13 and 1.34) and on chemical fertilization values were between (1.02 and 1.35).

**The number of leaves per plant.** Cultivars ‘Vima Xima’, ‘Viktoriana’ and ‘Virena’ achieved the highest number of leaves per plant and values varied between (12.50 to 11.96), which were not statistically assured. Regardless of cultivar, the highest number of leaves per plant was recorded in chemically fertilized system (10,12). Organic fertilization system recorded value was (8.78) leaves per plant.
The percentage of the binding flowers (%). Cultivar ‘Viktoriana’ recorded the highest percentage of binding flowers (46.12%) followed to significant difference by cultivar ‘Vima Xima’ with a rate of (44.70%).

Fruit size, weight (g). This character is appreciated by the average weight of a fruit and the ratio of the three dimensions, especially for fruit showing hollow. From the 10 studied cultivars biggest fruits were obtained from cultivar ‘Viktoriana’, with a weight (18.60 g) followed by cultivar ‘Vima Xima’ weight of fruit (16.84 g). The lowest average fruit weight was recorded by cultivar ‘Alba’ (11.28 g). Intermediate values in terms of fruit weight were obtained by cultivars ‘Premial’ (12.28 g), ‘Elianny’ (12.67 g) and ‘Vima Zanta’ (12.72 g). In agroteextila version mulch strawberry fruits showed a medium weight of (13.63 g). Between mulches with straw and black polyethylene there were no statistically differences assured, average fruit weight ranging from (14.05 g) to (14.19 g).

The fruit size determined by the index. After the average of the three dimensions of strawberry fruit it is considered to be: small (less than 3 cm), medium (3.0 to 3.5 cm) and large (over 3.5 cm). The highest fruit size was achieved in the variant with straw mulch (3.80 cm) followed by agroteextila mulch variant (3.62 cm) and the final version with black polyethylene mulch (2.99 cm). Regardless the types of mulch between the ten studied cultivars were differences assured, being influenced primarily genetic. The highest size index was registered by cultivar ‘Viktoriana’ (4.05 cm) and the smallest index by cultivar ‘Korona’ (3.08 cm).

Structo-textural firmness of strawberry. Structo-textural firmness was in the best variant of agro textile mulch (15.91 kgf/cm²), followed by the variant of straw mulch (14.27 kgf/cm²) and variant with polyethylene black mulch (13.82 kgf/cm²).

The strongest structo textural firmness was recorded by cultivar ‘Viktoriana’ (18.93 kgf/cm²), followed by cultivar ‘Vima Xima’ (17.38 kgf/cm²). The lowest structo textural firmness was obtained from cultivars ‘Vima Xima’ (7.57 kgf/cm²) and ‘Vima Zanta’ (8.39 kgf/cm²) that behave similar statistically speaking.

Adherence of calyx. Assessment was done by grades from 1-10, depending on the resistance to detachment of the fruit calyx. Depending on the scores given to each species that were grouped into five distinct classes, as follows:
- II - slightly – ‘Premial’.
- IV - strong – ‘Alba’.
- V - very strong, ‘Viktoriana’.

RESULTS UPON PRODUCTION AND QUALITY OF STRAWBERRIES

Production obtained in the first year of cultivation. Mulching with black polyethylene film secured the highest average yield in the first year (8.77 t/ha). Average yields on mulching with agrotextil was (7.1 t/ha), and on the straw mulch (7.12 t/ha).

The highest yield in the first year of cultivation was recorded in cultivar ‘Viktoriana’ (15.65 t/ha) followed by ‘Vima Xima’ (13.37 t/ha) and the lowest production ‘Alba’ (1.87 t/ha). The highest average yield was obtained in organic fertilization (7.99 t/ha). The average yield of chemical fertilization was (7.35 t/ha).

Production obtained in the second year of cultivation. The highest average yield was obtained in the variant mulched with agrotextil (18.32 t/ha), followed by the variant mulched with black polyethylene foil (17.86 t/ha) and the traditional mulching with straw (13.99 t/ha). Differences in production between variant agrotextil mulch and the mulch with straw (4.33 t/ha) and between the polyethylene foil and the mulch straw mulch (3.87 t/ha) is a strong argument in support of the recommendation to use in strawberry culture of the first two types of mulch: agrotextil and black polyethylene film.

The highest average yield was recorded by ‘Vima Xima’ (24.9 t/ha), followed by ‘Korona’ (24 t/ha), ‘Viktoriana’ (22.72 t/ha) and ‘Vima Zanta’ (21.24 t/ha). The lower yields were obtained by cultivars ‘Alba’, ‘Premial’, and ‘Kimberly’. The highest average production was obtained in organic fertilizer (18.21 t/ha) with a difference of (2.97 t/ha).

The beneficial influence of organic fertilization in strawberry culture directly reflected by increased fruit production by about 17% compared to chemical fertilization.

Cumulative production obtained in the two crop years. This indicator provides useful information on the productive potential of each cultivar and complex thereof can be calculated using the total revenues respectively cultivar cycle.
The highest yields were obtained by cultivars ‘Viktoriana’ (39.08 t/ha), ‘Vima Xima’ (36.88 t/ha), ‘Korona’ (27.05 t/ha), and ‘Virena’ (24.57 t/ha). Productions performed above 20 t/ha were ‘Vima Zanta’, ‘Elianny’, ‘Elsanta’ and ‘Kimberly’. The lower yields were obtained by cultivars "Alba" (13.08 t/ha) and ‘Premial’ (13.93 t/ha). The highest cumulative production was recorded on agrotextil mulch (25.4 t/ha).

Cumulative production obtained on polyethylene mulch was (24.9 t/ha), folowed by straw mulch (22.11 t/ha). The mulch with agrotextil gave an increase of production of (3.29 t/ha) compare with straw mulch and (0.5 t/ha) as compared to black polyethylene mulch.

**Average yield of strawberries in the experimental field.** The results provided by the average yield on the two experimental years (2012-2013), allowing a more accurate analysis on the productive potential of each cultivar, climatic and technological conditions in the experimental field. The highest average yield was obtained in the variant mulched with black polyethylene foil (12.51 t / ha), followed by mulching with agrotextil variant (12.41 t / ha) and the traditional mulching with straw (11.06 t / ha). The ranking of varieties, without taking into account the influence of mulch type in the production is as follows: ‘Viktoriana’, ‘Vima Xima’, ‘Korona’, ‘Virena’, ‘Vima Zanta’, ‘Elianny’, ‘Elsanta’, ‘Kimberly’, ‘Premial’ and ‘Alba’ The highest average yield was given by organic fertilizer (12.98 t / ha) with a difference of (1.97 t / ha).

**The content of total soluble dry matter, %.** Cultivar ‘Elianny’ (13.33%) recorded the highest percentage in total soluble dry matter content followed at significant difference by cultivars ‘Korona’ (13.20%) and ‘Vima Zanta’ (13.13%). The lowest values were recorded in total soluble dry matter by cultivars ‘Viktoriana’ (10.71%) and ‘Kimberly’ (11.92%) which behaved similarly, but with significant differences from previously analyzed cultivars.

**The average content in soluble solids content, %.** Soluble solids content in this experience ranged from (10.99 to 12.31). The highest percentage was recorded with agrotextil mulch (12.31%) and the lowest percentage was recorded with straw mulch (10.99%). Comparing cultivars, the lowest content in soluble solids content was registered by cultivar ‘Viktoriana’ (9.68%) and the highest content by cultivar ‘Virena’ (12.99%).
The medium content of sugar, (°brix). The highest sugar content was recorded with agrotextile mulch and black polyethylene mulch with (10.56 - 10.58 °Brix) and the lowest percentage was recorded with straw mulch (9.14 °Brix). Comparing cultivars the lowest sugar content was registered by cultivar ‘Viktoriana’ (7.87 °Brix) and the highest content by cultivar ‘Virena’ (11.43 °Brix).

Total titratable acidity, %. Total titratable acidity from this experience recorded values between (0.80% and 1.18%). From the ten strawberry cultivars the highest concentration of organic acids was registered by cultivar ‘Alba’ (1.18%) followed by the cultivars ‘Elsanta’ (1.06%) and ‘Premial’ (1.00%). The lowest concentration of organic acids was registered by cultivars ‘Vima Xima’, ‘Virena’, ‘Viktoriana’ and ‘Vima Zanta’ (0.80 - 0.82%). The highest value in total titratable acidity was recorded by variant with agrotextile mulch (0.98%) followed by variant mulched with straw (0.93%) and the latest variant mulched with black polyethylene foil (0.86%).

Vitamin C content. The highest value was recorded by cultivar ‘Kimberly’ (44.05 mg/100 g sp) and lowest by cultivar ‘Viktoriana’ (13.79 mg/100 g sp). The highest value was recorded on variant with black polyethylene foil (30.73 mg/100 g sp), followed by variant mulched with agrotextile (29.54 mg/100 g sp), and variant mulched with straw (27.19 mg/100 g sp).

Regardless of cultivar between the two fertilizers variants there were differences statistically assured. The highest content of vitamin C was recorded in organic fertilized (29.26 mg/100 g sp).

Results for resistance to major diseases. The lowest sensitivity to gray mold was recorded by cultivar ‘Elsanta’ and ‘Korona’ cultivar has the highest sensitivity. From the ten cultivars from this experience the highest resistance to powdery mildew was recorded by cultivar ‘Premial’. Cultivar ‘Alba’ has the highest sensitivity to white spotting of the leaves, followed in order by the cultivars ‘Premial’ and ‘Kimberly’. Among the varieties with resistance to the disease were noted cultivars ‘Vima Zanta’, ‘Viktoriana’ and ‘Vima Xima’.
RECOMMENDATIONS

- From the ten new strawberry varieties studied in this thesis, in specific climatic condition of Cluj we considered that cultivars: ‘Elianny’, ‘Vima Zanta’, ‘Korona’, and ‘Vima Xima’ are suitable for perennial crops in the field.
- Cultivar ‘Elianny’ has a longer growing season compared to the other cultivars, therefore we recommend shortening attention to fertilization. If this condition is not respected, there is a risk that the plants do not end the cycle of vegetation until the arrival of the first frosts, and the plants are damaged.
- Cultivars ‘Vima Zanta’, ‘Viktoriana’ şi ‘Vima Xima’ has a high resistance to white spotting leaves compared to cultivars ‘Alba’ and ‘Premial’ which are very susceptible to this disease.
- We do not recommend taking the culture of the cultivar ‘Virena’, because it has a very high percentage of up to 90% starting in achenes vegetation. (Anexa.)
- In order to increase production and fruit quality performance it is recommended for soil maintenance the mulch systems with agrotextil or with black polyethylene film.
- To provide the necessary of macro and micronutrients for the plants is recommended organic fertilization with poultry manure diluted to 20-25 parts water and soak for 14 days, which gave production increases and higher quality compare with chemical fertilization.
- The very good reaction of cultivars in organic crop, specific technological measures (mulch, organic fertilization, and disease control products approved organic culture) recommends these cultivars for organic farming.
- The results from this thesis recommend extending in culture of these varieties, not only in Transylvania but also in other areas of favorable conditions not only in people's gardens on small areas but also in industry.
- As temperatures under black polyethylene mulch are much higher, we strongly recommend installing two drip tapes per row of plants.